INFORMING ENVIRONMENTAL DECISIONS

First steps towards a Canadian Information System for the Environment

The Interim Report of the Task Force on a Canadian Information System for the Environment to the Minister of the Environment

Canada

The Honourable David Anderson
Minister of the Environment
House of Commons
Parliament Buildings
Ottawa, ON K1A 0A6

Dear Minister Anderson:

On behalf of the members of the Task Force on a Canadian Information System for the Environment, I am pleased to submit to you our interim report, *Informing Environmental Decisions: First Steps Towards a Canadian Information System for the Environment.*

As you are aware, environmental agencies across Canada are moving towards a new style of environmental management – one based on partnerships and the sharing of responsibilities, and one that recognizes the role of an informed public in achieving environmental goals. Although our recommendations at this stage are very preliminary, we believe a Canadian Information System for the Environment will provide a key foundation for that transition.

This report portrays our progress to date on a number of important issues central to the design and implementation of this information system. Its purpose is to engage interested parties, particularly the users and providers of environmental information, in a discussion on their environmental information needs and how best to meet them. We view this input as critical to our work in the second half of our mandate and to helping us formulate our final recommendations for submission to you in Autumn 2001.

Yours sincerely,

David Johnston
Chair, Task Force on a Canadian
Information System for the Environment

This interim report was prepared by the Task Force on a Canadian Information System for the Environment. The final report is expected in Autumn 2001.

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1. Introduction

Canada's natural environment is at the heart of our society. It is the legacy we pass on to our children.

To protect this legacy, we need information. Do we have enough information to recognize the effects of our actions on the environment, to understand the effects of the environment on our health, to adapt to environmental changes, and to tell whether we – government, the private sector, our communities and ourselves – are doing a good job in protecting this natural heritage?

Most people would agree that we do not. Indeed, as pressure on the environment intensifies and new ways of environmental management emerge, it has become necessary for governments, as well as citizens, communities and the private sector, to have ready access to high-quality environmental information to support their decisions.

In this chapter, we explain why we believe it is important to develop a Canadian Information System for the Environment (CISE), the problems that we think CISE should address, and the resulting benefits to Canadians. In later chapters, we provide our preliminary thinking on the structure of CISE, the functions we believe it should have, and some of the methods that could be used to meet those functions.

The Need for CISE

A new way of managing the environment has emerged over the last few years. This approach stems from the recognition that today's complex, multi-dimensional and increasingly global environmental issues – such as climate change, depletion of the stratospheric ozone layer, genetically modified organisms, endangered species and habitat loss – transcend government jurisdictions and demand new and innovative strategies.

Environmental agencies in Canada and elsewhere have acknowledged the need for change, and each is now struggling with how to make that transition. This is accompanied by the growing acceptance that governments cannot do it all, coupled with an increasing awareness that an informed public, with access to environmental information, is a prerequisite to achieving environmental goals.

Environmental agencies are moving towards a climate of partnership, developing strategies that cut across government departments and jurisdictions and engage the private sector, non-government organizations (NGOs) and the public. They are establishing mechanisms for sharing responsibility, including ensuring that information is available in forms that can be readily used and understood. They are moving towards a "place-based" approach, with boundaries that make environmental sense, such as those for ecosystems or watersheds.

These efforts have been facilitated by recent advances in information and communications technology that have created a digital world where it is much easier to gather, analyze, integrate and share environmental information amongst decision-makers, the general public and other stakeholders across the country. Canada, as one of the most connected countries in the world, and as a world leader in the use of geographic information systems and satellite-based remote sensing technology for data collection, is well positioned to take advantage of this opportunity.

The transition to partnerships, shared responsibilities and place-based approaches, coupled with the new information and communications technology to facilitate that transition, requires the support that CISE can provide. CISE will enable governments and stakeholders to share and integrate information and to provide it in a form that is readily accessible, understandable and usable by those who need it.

Problems for CISE to Address

While several environmental information initiatives have been undertaken in recent years, there is still much to be done by everyone to successfully make the transition to the new style of environmental management. Some of the key information challenges that we believe CISE should address are identified below:

- Canadians do not have an adequate picture of the state of their environment or of the health of Canada's environmental management system. They cannot compare environmental conditions in one part of Canada with those in another, nor can they hold governments accountable for their actions.
- Environmental information is frequently difficult and expensive to access. Current efforts do not ensure that information is available to those who need it.

Serious Gaps in Monitoring Water Quality

There is currently no national water quality monitoring program in Canada. A national water quality methods manual has not been in place or updated since the late 1980s, leading to the use of a wide range of methods across Canada for water quality monitoring. This lack of standard protocols limits the interpretation and integration of results. As a result, Canadians and governments do not have a comprehensive, national picture of the quality of Canadian waters.

Serious Gaps in Monitoring Biodiversity

To prevent the loss of species, we must know what species we have, where they occur and what their status is. While there are more than 70,000 species known to live in Canada, there are probably about as many again still undescribed by science. In the recent report ***Wild Species 2000****, the first report on the general status of species in Canada, only 1,600 species were able to be assessed.*

- An efficient means of sharing environmental information between providers and users does not exist in many cases.
- There is much duplication of effort between the many different levels of government and others that collect and store environmental information.
- There is little consistency among existing data due to a lack of standard protocols for information collection and management. It is difficult and expensive to integrate such data into a form required to meet the needs of most decision-makers.
- Current processes for defining and responding to new information requirements are ineffective. Governments, NGOs, the private sector and communities spend several hundred million dollars a year on environmental information. However, the gap between what they have and what they need is growing.
- Policy-makers and the public are often distracted by the latest issue. As a result, the effectiveness of program implementation, the existence of future threats, and the potential of strategic opportunities may go unnoticed.
- Canadians have a profound lack of knowledge of many environmental issues. They often are not aware of the environmental information that exists. When they do find environmental information, it is frequently not presented in a way that is understandable or usable by them.
- Many government and non-government initiatives that have focused on information-based campaigns to foster environmentally responsible decisions by Canadians have been unsuccessful. Although these campaigns may result in increased awareness, they represent an ineffective use of resources, particularly at the local level.

Benefits of CISE

If CISE addresses these problems, the benefits that will be realized are considerable. Of most significance are the enhanced ability to achieve environmental goals and the more efficient use of resources in doing so.

More specifically, an information system that ensures easy and timely access to shared and integrated environmental information by governments, citizens, communities and the private sector should result in:

- continuous improvement in government and private sector environmental performance;
- a reduction in the overlap and duplication amongst the many different levels of government and others that collect and store environmental data and information;
- a more rational and user-driven approach to identifying and filling the serious gaps that now exist in environmental information;
- an improved ability of environmental agencies to make the strategic shift to place-based planning and decision-making;
- increased innovation amongst the regulated community as it is given more freedom to achieve agreed-upon environmental goals;
- reductions in the burden of reporting on government agencies and the private sector;
- an increased capacity of governments to anticipate environmental changes and take early action;
- enhanced information and tools for setting policy priorities;
- an enhanced ability to understand the social and economic implications of environmental policy choices;
- an enhanced ability to provide credible, up-to-date information for reporting on the environment by all levels of government; and
- enhanced citizen and community involvement and an increase in environment-friendly behaviour by Canadians.

This report provides our preliminary thinking as to how we believe CISE can achieve these benefits. We are seeking your comments and advice to help shape our final recommendations.

2. Envisioning CISE

As described in the previous chapter, we are convinced there are tremendous benefits to be gained by improving the amount and quality of environmental information available to Canadian decision makers. But what must be done to realize these benefits? In this chapter, we lay out some of the basic foundations we believe should guide the design and implementation of CISE. The chapters that follow will then begin to build on these foundations to outline CISE's essential components.

Principles

The emerging approach to environmental management suggests certain principles that help define a strategic role for information:

- The purpose of an environmental information system is to provide the information Canadians need to make responsible environmental decisions. The focus should thus be on information with the greatest impact on **decision making**.

- Environmental decisions are **place-based**. They must be attuned to the specific characteristics of particular geographic regions. Information must be responsive to the need to make decisions at **many spatial levels** – from neighbourhoods to global.
- Environmental systems are inherently complex, and environmental issues are closely interconnected. Thus, our knowledge of the natural environment will always be incomplete and a high level of **uncertainty** will always be a feature of environmental decision making.
- Environmental information in CISE must be **credible** and **verifiable** and not associated with promotion of particular points of view.
- Information must be both **retrospective** and **forward-looking** so that decision makers can understand the opportunities that are available and the consequences of their decisions. Information must be responsive to **many temporal scales**, from minutes to decades.
- Information for decision-making should be **timely** and **affordable** to those who need it, and communicated to Canadians in a manner which is **understandable**, **efficient**, and **transparent**.
- Because citizens have a right to know about how the environment may affect them and how they can prevent or adapt to these impacts, environmental information should be viewed as an **essential public good** readily available and accessible to all Canadians.

Data, Information and Knowledge

It has become common to distinguish between data, information and knowledge, as illustrated in Figure 1. Though it may not be possible to draw a clear line between the categories, the division is helpful.

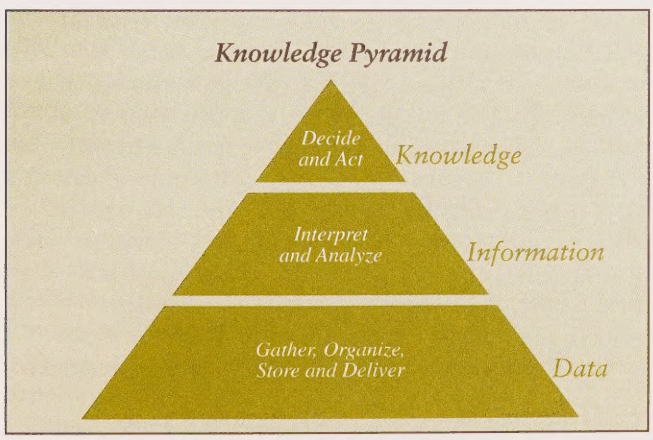

Figure 1

Data can be defined as basic observations or measurements. They have no particular physical form, but can be transmitted, combined and analyzed using a variety of tools. **Information** refers to the products of analysis and interpretation. Often, these have definite physical or electronic form. They could include documents, reports, administrative records, photographs, sound and video recordings, and so on. **Knowledge** is information in the mind, in a context that allows it be transformed into action.

For example, weather data could include measurements of wind speed, temperature and precipitation at a particular location, time and date. Weather information would include the short and long-term forecasts generated by analyzing and interpreting large quantities of data with predictive models and through the application of expert knowledge. Knowledge in this case includes the experience and judgement of the meteorologists providing the weather forecasts, as well as the institutional processes enabling them to warn Canadians of danger, facilitate smart transportation systems and explain the requirements for adaptation to climate change.

We propose that CISE focus on:
- the gathering, organization, storage and delivery of environmental data, and
- the systems needed to transform these data into useful information and disseminate it.

Thus, CISE would not focus directly on many of the issues arising under the heading of "knowledge management". These issues are certainly important and are more visible and understood by the public – we strongly encourage federal departments and other environmental organizations to investigate them further. However, we believe our first priority should be improving the management of data and information to ensure a strong foundation for environmental knowledge in Canada.

Traditional and local ecological knowledge represent an important exception to this rule. Both are proving vital to understanding, and managing human use of, the natural environment. Both are now underrepresented in existing information systems. Strengthening the capacity of communities to manage, use and maintain the integrity of traditional and local knowledge should be a key part of CISE.

Scope of Environmental Information

Our mandate directed us to consider information concerning Canada's natural environment, as well as linkages to other information systems – such as those for health, social and economic information – though not to identify investment needs in these last areas. Though not mentioned explicitly, we have interpreted this mandate to include information

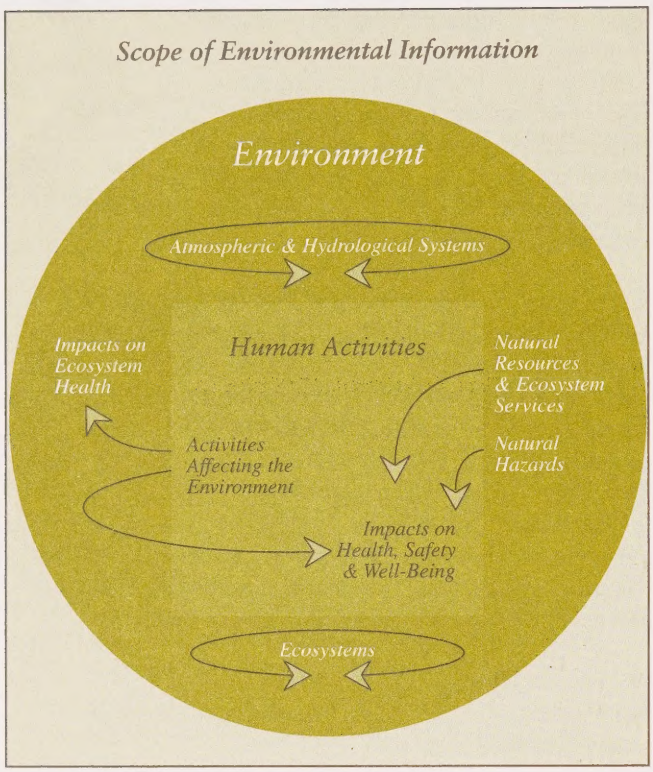

Figure 2

about how human activities affect the natural environment, how natural processes affect human well-being, and how people affect one another through changes they make to the natural environment.

Figure 2 illustrates the various kinds of information relevant to environmental decision making.

- **Ecosystems** – the variety of living organisms on land and in water (biodiversity), the abiotic components of ecosystems, and the interactions between them.
- **Natural resources and ecosystem services** – those aspects of the natural environment which benefit humans, including stocks and flows of renewable and non-renewable resources, and the services derived from the functioning of ecosystems.
- **Atmospheric and hydrological systems** – air and water, and the natural cycles and processes that generate weather and climate phenomena.
- **Activities affecting the environment** – human actions that affect the natural environment positively or negatively, including the release of wastes and other substances to the environment, physical alteration of land and waterways, transfer of material or species from one place to another, environmental management actions, and ecosystem restoration.
- **Natural hazards** – natural processes that may affect human welfare, including storms and other weather events, floods and droughts, forest fires, and earthquakes and other geological hazards.
- **Impacts on health, safety and well-being** – the benefits humans receive from the environment, as well as the effects of natural hazards and environmental changes caused by human activities, including impacts relating to health and safety, economic costs and benefits or social and psychological benefits.
- **Impacts on ecosystem health** – the effects of human activities on air, water, biodiversity and other aspects of ecosystems, both positive and negative.

This list does not represent a rigorous conceptual framework of the kind required to organize and manage data and information, or to permit the development of common standards. Given the wide range of environmental information, it is not surprising that many different frameworks are used to guide data collection and analysis. Generally, these are developed to feed specific predictive models or decision making needs, or to enable coordination with other organizations within a particular domain. Such is the case with weather forecasting, flood prediction, forest management or risk assessment.

At this point, we are not certain a single conceptual framework will be sufficient to address the range of environmental information included within the CISE mandate, especially given the need to support decision making at various spatial scales and time periods. We are continuing to examine options for conceptual frameworks, including those based on a natural capital approach as well as the "pressure-state-response" frameworks widely used for the organization of environmental indicators. Annex B includes brief descriptions of these conceptual frameworks.

An important outstanding issue concerns how to identify which elements of the natural environment should be measured and which of these data sets should be included within CISE. The issue is controversial because it raises fundamental questions about the value of ecosystems and their components. Should CISE incorporate all the environmental information listed above, or only certain kinds of information? Given the evolving nature of environmental decisions, we anticipate that CISE will need to include an ongoing, consultative process for determining information priorities. We also hope to provide an initial answer to these questions in our final report.

Environmental Information Systems – An Overview

In the course of our discussions, we examined environmental information systems developed by other departments and agencies in the federal government, in provinces, and in other countries. While none provided

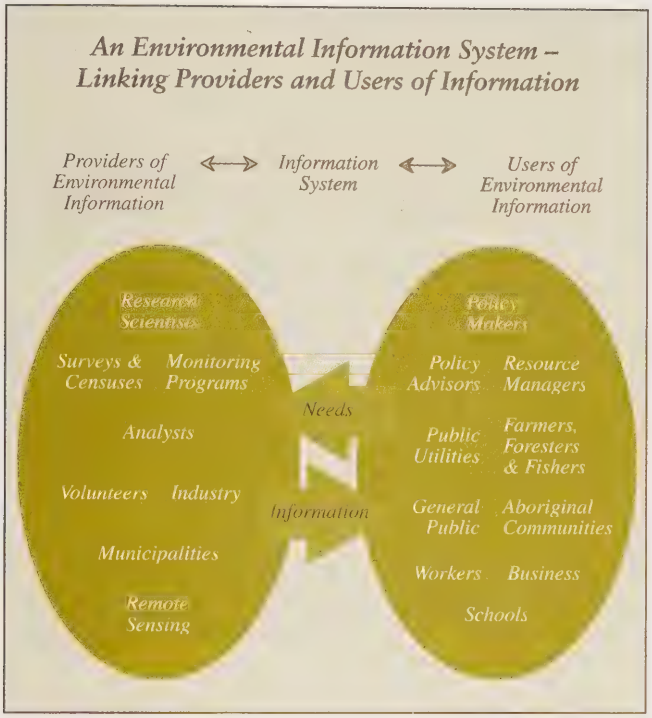

Figure 3

us with a single model for what we have been asked to do, many have strengths we believe should be incorporated into CISE.

It is also clear, however, that there are many different views as to what constitutes an environmental information system. These differences make it essential we describe at least our initial conception of the system.

We view an information system as essentially a means to allow providers and users of information to communicate with one another. Data and information provision can then be adjusted to meet the needs of users, while users can determine their information priorities in light of the costs and constraints associated with providing that information. Figure 3 illustrates this view.

While easy to state, implementing this vision is complex. Both users and providers of environmental information are heterogeneous, including many different groups with varying needs, requirements, technical knowledge and access to resources. In many cases, it may be hard for members of these groups to articulate clearly their information needs. As well, these needs change over time in response to environmental changes and increasing understanding.

Another consideration is the large number of existing regional or special-purpose environmental information systems now in operation or under development in Canada. These systems, while impressive in themselves, cover only a portion of the geographic area needed for a national system or provide a national picture with respect only to a particular resource or aspect of the environment. As well, it is crucial that the ability to share and use information from these various systems be improved.

We believe it is neither feasible nor desirable for environmental data and information to be managed by a single organization. Most environmental data are collected to support specific policy or operational decisions, however useful it may be for other purposes and other users. Jurisdiction over environmental management is shared between the federal, provincial and territorial levels of government. Many departments and agencies within each jurisdiction have responsibilities related to the environment. In addition, negotiated self-government arrangements often enable Aboriginal governments to exercise law-making authority with respect to the environment. Other organizations, private and public, also produce environmental information to meet their own requirements. In our view, it would not be prudent to jeopardize the present close connections between the users and providers of this information.

The system we propose resembles a network of environmental information systems, sometimes called a "distributed system" (Figure 4). Present information systems would continue and the organizations responsible for their operation would retain control of them. The focus for CISE should be to

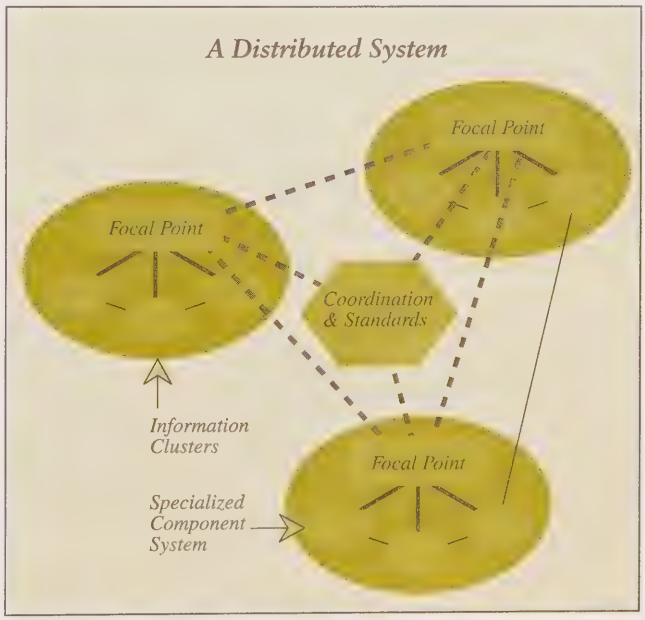

Figure 4

Examples of Environmental Information Initiatives in Canada

GeoConnections *(Natural Resources Canada)*
National Pollutant Release Inventory *(Environment Canada)*
Canadian Soil Information System *(Agriculture and Agri-Food Canada)*
National Forest Information System *(Canadian Council of Forest Ministers)*
Integrated Data Management Initiative *(Province of British Columbia)*
GéoSélection *(Province of Quebec)*
Environet *(Ontario Ministry of the Environment)*
NatureServe *(Association for Biodiversity Information)*

develop the mechanisms and institutions for facilitating dialogue and the sharing of information among these systems, with a view to growing an ever greater ability to integrate and use environmental information from multiple sources. CISE should also enable priorities to be set for filling significant information gaps.

The size of this task should not be underestimated. There are many institutional and technical barriers to overcome before realizing the benefits of integrated environmental information. One advantage to this approach is that it may be implemented in a phased way, building where consensus and agreement can be reached in accordance with a comprehensive vision.

Many questions remain about how this system would operate. Should information be clustered in terms of regions (e.g., provinces and territories), environmental components (e.g., biodiversity, water), policy issues (e.g., climate change), or some combination? How important is it to have strong, central coordination for the system? Should there be a core set of environmental information, organized in a rigorous conceptual framework, even if this means changing existing monitoring and data collection programs? In what order should components of CISE be developed? We will need to understand the implications of these and other issues so that we may provide clear direction on the design and implementation of CISE in our final report.

A further question relates to the governance of CISE. We have already started exploring a number of inclusive models, including those for health information and justice statistics. In both these examples, the relevant federal, provincial and territorial agencies play a key role in determining the overall direction of the programs. No doubt other models deserve consideration, and we welcome your thoughts on this important issue.

3. Building the Data Resources

In the previous chapter, we identified the differences between data, information and knowledge, and put forward our preliminary thinking on the structure and governance of CISE. In this chapter we address the bottom tier of the knowledge pyramid, the data resources layer. We provide our initial proposals on the infrastructure, on who should form the partners of CISE, and of the types of standards and agreements that we feel CISE will require. We also look at the current state of environmental monitoring and research in Canada, as they are key to providing the data resources for CISE. Finally, we explore the importance of traditional and local ecological knowledge to CISE.

Building the Infrastructure

As stated in Chapter 2, CISE would be a distributed system composed of many partners who would join on a voluntary basis. These would include:

- federal, provincial and territorial agencies involved in the collection and maintenance of environmental data or engaged in systems development and support important to CISE;
- the private sector;
- municipalities;
- academia;
- non-governmental organizations;
- Aboriginal communities; and
- organizations in other countries.

We expect that CISE will involve an ever increasing number of partners as direct experience of the benefits to be derived from participation grows.

Partnership in CISE will involve responsibility, though the degree will be determined by partners. At least in the early stages, many of these responsibilities will likely be spelled out in formal data sharing agreements between data providers and users to ensure the concerns of both sides (about, for example, data quality, security, and ownership) are understood and have been addressed. These arrangements constitute a positive way of increasing trust and fair dealing amongst partners.

Standards will be central to a distributed system such as CISE. Several different types of standards will be needed to enable the transition from the current project-based way of collecting and managing data to a strategic information infrastructure that will inform decisions. Our role as a task force is not to define specific standards; these should be

developed through a consultative process with CISE partners. We will, however, identify some of the priority requirements for standards. These include:

- standards and protocols for data collection;
- standards for data sharing (or exchange), including standards for data quality, content, maintenance and metadata; and
- technical standards for the integration of data.

It will not be easy to achieve compatible standards, nor will these be developed quickly. Investment will be required to develop standards and build the capacity of partners to adopt them. It will also be important to ensure compatibility with international standards so that data can be shared and integrated across national boundaries. Many countries now recognize the need for common environmental data standards and some Canadian programs already use nationally or internationally accepted standards, for example, standards for weather data developed by the World Meteorological Organization.

Although CISE should be standards-based, its infrastructure should be technology-neutral. In other words, it should be based on standardized Internet language that allows individual agencies to invest in internal information management systems of their choice at a pace they can afford. Some agencies already have such systems in place, thereby establishing the foundations for allocating resources to create links, fill important gaps, and introduce standardized practices. In other words, while it will not be necessary to build a large-scale technology infrastructure from the ground up, some investment will be needed.

Recommendation

1. Implementation of CISE should involve:

a. developing a distributed system that will link CISE partners and deliver information to all who need it;

b. developing partnerships with federal, provincial and territorial agencies collecting and maintaining data on the environment or engaged in systems development and support relevant to CISE system requirements, as well as the private sector, municipalities, academia, NGOs, Aboriginal communities and international organizations; and

c. applying or, where needed, developing standards and protocols for data collection, standards for data sharing (including standards for data quality, content, maintenance and metadata) and technical standards for the integration of data.

Accessing and Developing the Data for CISE

The environmental information contained in CISE, as briefly discussed in Chapter 2, will come from data gathered through monitoring, surveys, research, permits and numerous other sources. When the implementation priorities for CISE have been decided, it will be critical to develop a strategy for accessing and developing data. This strategy will necessarily involve an assessment of available data sources, data quality and present standards and formats, as well as an identification of data gaps.

The strategy should also identify and prioritize the backlogs of data requiring processing. For example, in the case of climate records, there are up to five years of gaps in the data sets due to the lack of data processing. Similarly, the strategy will have to identify priorities for retrieving and digitizing certain databases (such as ice thickness measurements and biological information) so that valuable data can be "mined" from existing monitoring programs and made more readily available to users.

The preliminary analysis of data gaps in Annex C demonstrates that much of the information needed to make effective policy decisions in areas such as water and air quality and biodiversity is not available. In some cases, monitoring programs do not exist. In others, they have been considerably reduced in the last decade. Indeed, as a result of fiscal constraints, several of Canada's monitoring systems have become increasingly outdated and unable to take advantage of new scientific and information technologies.

Over the next several years, governments will have to invest heavily in research and monitoring to protect the health of Canadians and the health of Canada's ecosystems. We believe that CISE represents an opportunity for a more rational and user-driven approach to identifying and filling the serious gaps that now exist in environmental information.

Better Information from Better Monitoring

Environmental monitoring and surveys are designed to provide us with an early detection and warning system and inform us about the status of the environment. They tell us whether our actions can or will have an impact on the environment and whether the environment is having an impact on us. In addition, monitoring allows us to determine if preventative, mitigative or remedial activities are resulting in desired outcomes. We believe the needs of CISE users should represent a crucial input into monitoring priorities.

Serious Gaps in Monitoring Environmental Change

"Government-supported monitoring of environmental changes has significantly decreased – making us less able to track and deal with existing environmental concerns and predict new ones. The recent contaminated water tragedy in Walkerton, Ontario, is an illustration of this. In the future, our quality of life will increasingly be linked to the health of our environment – as will the success of our economy."

Achieving a Balance
National Round Table on the Environment and the Economy,
February 2001

Canada has a number of environmental monitoring and survey programs run by all levels of government, NGOs and the private sector, sometimes in isolation, sometimes under a variety of partnering arrangements, but frequently with few points of coordination or integration. The data collected at best provides a very dispersed picture at a national level of "what has happened", and not necessarily an integrated picture of "the status and trends" of environmental change nor an integrated base of information on which to forecast "what will happen" in the future. As a consequence, monitoring programs do not provide the basis for the integrated environmental information needed to meet today's environmental challenges. For this reason, we strongly support a more integrated approach to environmental monitoring across the country. The *Statement of Principles to Guide Cooperative Arrangements on Environmental Monitoring and Reporting* proposed by the Canadian Council of Ministers of the Environment provides a useful first step in this direction.

Recommendation

2. In order to fill serious gaps in the information required for environmental policy decisions, implementation of the CISE should be accompanied by:

a. a collaborative effort to develop an integrated national environmental monitoring system (including water, climate, air, wildlife/biodiversity, and other natural resources), comprised of a network of interoperable and compatible monitoring networks that would meet information needs at all levels;

b. investment in modernizing and sustaining existing national environmental monitoring networks; and

c. increased resources for filling priority information needs, examples of which are provided in Annex C.

Better Information from Environmental Science

After more than two decades of steady growth from the 1970s to the mid-1990s, investment in environmental science and research has recently leveled off and even declined. Concern is mounting that, as currently funded and organized, Canada's environmental sciences research system will not be able to meet expanding demands for the information needed to support decision-making. Nor will this research system be able to provide the services Canadians depend upon or develop the new technologies required to support sustainable development.

The situation demands a greater emphasis on establishing partnerships and networks to improve effectiveness. It calls for a means to develop common objectives and science priorities for Canadian environmental science. Over the past few decades, many effective research networks have emerged, usually within specific areas or disciplines of environmental science. The need exists to link these networks and set an overall national agenda for environmental research and a more rationalized federal investment strategy for the environmental sciences.

Environment Canada is now working towards establishing a Canadian Environmental Sciences Network (CESN) to build on this networking activity and provide a common horizontal management framework. Such a multi-stakeholder network would provide a national point of contact between researchers and users of their work. It would also allow a dialogue to emerge on national priorities for environmental research and monitoring in Canada. We applaud this initiative and see it as an important step forward in helping shape a national agenda.

Recommendation

3. The proposed Canadian Environmental Sciences Network should be a key mechanism used by CISE partners to provide a coordinated multi-sector approach to determining and fulfilling research and monitoring priorities.

Traditional and Local Ecological Knowledge

Scientific discussion of the environment has long paid too little attention to the traditional (or "naturalized") knowledge of Aboriginal peoples and to the local ecological knowledge possessed by fishermen, hunters, loggers and farmers. This kind of knowledge can provide a vivid, holistic and detailed picture of local environmental situations that research and monitoring often cannot supply. CISE should incorporate such knowledge and encourage its preservation and use.

After consultation with Aboriginal communities, we hope to recommend measures to preserve and use naturalized knowledge, which can only be collected, analyzed and interpreted by Aboriginal peoples. To this end, as noted

in the preface, we have asked the federal Minister of the Environment to appoint to this Task Force an Aboriginal member who can carry forward such consultations with Aboriginal communities and can develop the appropriate recommendations for CISE.

4. Enabling Effective Environmental Policies

In our mandate we were asked to examine ways in which CISE could help strengthen the basis for sound public policies and provide a credible foundation for holding governments accountable with regard to their environmental management responsibilities. As the discussion of the scope of CISE in Chapter 2 indicated, the range of environmental information and environmental policy decisions is extremely broad. Environmental policy is also characterized by strong divisions between sectors – for example, between pollution prevention and resource management, or between fisheries and forests. These factors constrain our ability to examine information needs for specific policy decisions in detail.

In the present chapter, we focus on cross-cutting requirements that support an integrated and strategic approach to environmental management or are common across policy sectors. We believe that information available through CISE will have the greatest impact at the beginning and end of the policy cycle – that is, when identifying and prioritizing issues and assessing the effectiveness and efficiency of environmental policies and programs.

One concern frequently expressed, both within and outside government, is the difficulty in assessing and synthesizing the vast amount of data and information required to understand environmental issues. For this reason, we have chosen to direct our attention in this chapter to the second tier of the knowledge pyramid – the challenge of turning data resources into useful information. Many tools have been developed for this purpose and are used by environmental and natural resource departments and others to facilitate their work. These include mapping and spatial analysis tools, integrated assessment, and cost-effectiveness analysis. Here we draw attention to a small number of tools that have proven essential to modern environmental management: accountability reporting, indicators, predictive models, risk analysis and environmental accounting. Each of these tools is necessary, not only for making effective use of the data resources of CISE, but also in the identification of priorities for the further development of those resources.

Holding Governments Accountable

Canadians want to know whether governments are fulfilling their environmental responsibilities. In practice, this kind of accountability involves two types of reporting: reporting on environmental trends and conditions, often called "state of the environment"; and reporting on the effectiveness and efficiency of policies and programs, or what might be termed the "health of the environmental management system".

State of the environment reporting has flourished in Canada over the past decade and a half. Many federal departments, provinces, territories and municipalities provide reports on selected aspects of the state of the environment, and much can be learned from this experience. However, the information currently reported suffers from several constraints:

- It is difficult to compile a reasonably complete picture of environmental conditions across the whole of Canada.
- It is difficult to compare reported environmental conditions in one part of Canada with another.
- It is difficult to track progress on issues over a multi-year time period because of the lack of continuity in reporting.
- It is difficult to obtain assurance that reports are not coloured by the interests of organizations with policy responsibilities.

Serious Gaps in Monitoring the Great Lakes

"Without data and information from a full range of sustained and consistent environmental monitoring and surveillance programs, the governments, the public and the Commission are not in a position to identify issues that threaten human and ecosystem health, to choose effective solutions, and to assess whether progress is being achieved."

10th Biennial Report on Great Lakes Water Quality, International Joint Commission, June 2000

Reporting on the health of the environmental management system is in general not as advanced as state of the environment reporting. Many jurisdictions have introduced formal mechanisms for performance reporting, such as Departmental Performance Reports in the federal government and the "Measuring Up" initiative of the Province of Alberta. As with state of the environment reporting, however, Canadians will find it difficult to assemble a Canada-wide picture of environmental management or to compare performance on key indicators.

We are convinced that CISE can play a role in improving the quality and credibility of reporting to Canadians about the environment. At the same time, we recognize that performance reporting must avoid drawing facile comparisons without considering the various contextual factors that influence environmental conditions in different regions. We also believe that accountability to citizens should not be separated from the jurisdictions responsible for taking action. More discussion is required, however, to determine the most appropriate format and institutional arrangements for environmental reporting.

Recommendation

4. Implementation of CISE should involve establishing mechanisms for comprehensive, comparable, continuous and credible reporting to Canadians on:

a. the state of the Canadian environment; and

b. the effectiveness and efficiency of environmental management in Canada.

Indicators for Assessing Environmental Action

Indicators, because they enable the synthesis of complex information and its communication to diverse audiences, are an important tool for both setting measurable policy targets and assessing performance. Yet there are many different kinds of indicators, and each has its own role in supporting policy assessments and accountability.

National environmental indicators are useful for providing a broad picture of national environmental conditions and a basis for international comparisons. Canada has successfully promoted such indicators abroad, but we still lack a reasonably comprehensive set to report on the state of our own environment. The reason is that the data are unavailable or it is unclear to us what indicators are appropriate. While indicators must be expected to evolve over time, others have shown that greater progress in this area is possible. We believe development of CISE should spur completion of an initial set of national environmental indicators sufficient to meet international reporting requirements and domestic policy needs and ensure data are available to support these indicators.

Canadian governments also use indicators to track the effectiveness and efficiency of their policies and programs at the provincial, regional and national levels. The tasks of identifying and using such performance indicators should remain with the governments and other organizations with environmental management responsibilities. CISE can play a useful role, however, in facilitating the use by organizations of comparable ways of assessing performance. Such approaches would provide a basis for identifying best practices and effective solutions and for comparing the effectiveness of environmental action in different jurisdictions across Canada.

The National Round Table on the Environment and the Economy (NRTEE) is now developing, pretesting and promoting a set of indicators to measure certain aspects of Canada's progress toward sustainable development. A priority in implementing CISE should be the availability of environmental data to support this set of indicators.

Recommendation

5. As a foundation for enhanced accountability to the public and better policy assessment, implementation of CISE should include:

a. completion of a set of national environmental indicators, as well as the data sets to support them, in order to meet domestic policy needs and international reporting requirements;

b. mechanisms to improve comparability in performance indicators; and

c. environmental information to support national indicators of sustainable development.

Tools for Creating Better Policy

While the intent of indicators and accountability reporting is the improvement of environmental policy, their focus is necessarily on the past. Other tools are needed to provide information that is forward-looking and anticipatory. Several are so fundamental they should be considered as integral requirements of CISE:

- models explaining and predicting the connections between human actions, environmental change and human health;
- information and tools to assist in setting environmental priorities; and
- tools for integrating environmental information with economic and social information.

Environmental policy assumes we can anticipate the future and change course towards a more desirable future. Among the basic policy tools, then, are predictive models based on scientific understanding of the environment and human interactions with it. Models developed in Canada accurately predicted the impacts of certain chemicals on the ozone layer, providing the basis for Canadian regulations and international agreements. Though prediction can be uncertain, predictive models continue to improve, as do their usefulness in policy analysis. Such tools should be

used to generate information made available through CISE, though with indicators as to the confidence that can be placed in their predictive power.

Setting priorities is a fundamental part of environmental policy making and can be controversial because deeply held values are often at stake and the costs of action or inaction potentially enormous. While no simple formula for setting priorities exists, risk analysis provides an approach that can inform decision making and clarify choices. We believe that CISE should include information on the sources and severity of environmental hazards, the human populations or environmental components exposed, and public perceptions of risk as essential context for understanding policy choices. For example, better information is needed about risks from toxic substances, risks to biodiversity and risks associated with climate change. Improved methods for communicating risk information should also be developed.

An understanding of the ways in which the environment contributes to human welfare and how human activity can increase or diminish this capacity is of key importance to environmental policy. Statistics Canada has done valuable work on a natural capital model and a system of environmental accounts that allow rigorous examination of this relationship. In the view of the Task Force, CISE should support federal leadership in refining the natural capital model, and provide data for its implementation.

Recommendation

6. In order to help decision makers interpret and analyze environmental data, CISE should foster the development and use of:

a. models to explain and predict the connections among environmental change, human actions and human health;

b. information tools to understand and communicate environmental risks as a basis for setting policy priorities; and

c. a natural capital approach to environmental accounting.

5. Engaging Citizens and Communities

As part of our mandate, we were asked to consider the information needed by Canadian citizens and organizations so that they can adapt to environmental change and play their individual and collective roles in environmental management. As noted in Chapter 1, governments are moving toward allowing broad participation in environmental planning and priority setting, as well as towards place-based approaches to environmental management. They also increasingly recognize that an informed public can play an effective role in achieving environmental goals. Environmentally informed citizens are effective, not only because of their own actions, but also because they can hold governments and other organizations accountable for their environmental decisions and actions.

According to surveys, Canadians most want to know how the environment affects them personally – that is, in their local communities and in terms of their health and that of their families. They also want to be involved in improving the situation, as well as holding government, the private sector and themselves accountable for their impact on the environment. Yet despite the abundance of environmental information presently available and the desire Canadians express for environmental information, they have a profound lack of knowledge on many environmental issues. Simply put, Canadians are not aware of existing sources of environmental information, and that information is frequently not presented in a way that will be noticed, understood and used by them.[3]

In this chapter, we address how data and information – that is, the bottom and middle tiers of the knowledge pyramid – can be made accessible to citizens, communities and other users of information. Also considered here are methods of raising the awareness and encouraging the involvement of citizens and communities so that they will be empowered by the available information.

Accessing Environmental Information

The Internet is a powerful tool for individuals or organizations engaged in disseminating or using information. Yet Canadians looking for environmental information on the Internet must search many sites and there are generally no guarantees as to the quality, reliability and trustworthiness of the information they find. The Internet, because of Canadian's growing access to it, provides an important tool for partners in CISE to disseminate environmental information. We envisage CISE, through its distributed system of information providers across the country, taking a leadership role and establishing itself as the premier source for Canadians of "environmental information you can trust".

3 See Environics International, *Empowering Citizens: Secondary Research in Environmental Information* (Prepared for the CISE Task Force, February 2001).

Accessed via the Internet, any citizen should be able to locate easily environmental data and information that has met CISE criteria as to quality, reliability and credibility. Emphasis would be upon providing local information in a relevant and usable form, although regional, national and global information would also be available. The information should be comprehensive, understandable and query-driven. The data should also be up-to-date, while information on weather, air quality, water quality and their potential health and other effects should be available almost immediately – that is, in time for people to respond appropriately.

Innovative tools for searching, presenting and mapping information against geographic areas should make it easier for people to find and display the information they need, when they need it, and how they need it. The system should also allow people to interact with the data sets so that users can undertake further analysis and communities have the opportunity to share traditional and local ecological knowledge.

The Power of Internet Based Information – Pollution Watch Web Site

Making available credible information allows users to access, analyze and make use of the information in innovative ways that may benefit other citizens, for example by raising awareness of issues or encouraging accountability. For example, in April 2001, Canadians received access to a new web site (www.scorecard.org/pollutionwatch/) that will allow them to type in their postal codes and access information on the type and quantity of pollutants being released in their community and potential health risks. Using mapping techniques the user can then select location-specific information. The site merges data from surveys conducted for Environment Canada's National Pollutants Release Inventory with about 300 publicly available databases.

As indicated in Chapter 2, it will be critical to address questions of scope and content because of the potentially vast number of environmental issues that could be included in CISE. We see the decisions on content being guided by the principles outlined in this report and discussions with CISE partners and users. All should be involved in the design, on-going review and decisions on what issues and information are included and their respective priority. How the public accesses this information will require further consideration and should be based on the decisions with respect to content, the types of partners involved in CISE, and the information and data that data providers wish to make publicly available. Options for access to the information could include, for example, a single window access or multiple entry points.

Although we are proposing establishment of an environmental information system on the Internet, we recognize that the use of alternate media, formats and languages – including direct access to expert advice – reflecting the needs and varied preferences of Canadians will be necessary. Special provision will also clearly have to be made for Aboriginal and other communities in rural and remote areas where Internet access may be problematic. Finally, CISE should remain flexible and adaptable to take advantage of existing and future technological developments such as virtual fora and electronic town halls where all environmental stakeholders and the public can locate, discuss and share services, successes and information on issues.

Recommendation

7. CISE should provide access by citizens via the Internet to a wide range of environmental information that:

a. is developed by itself and its partners;

b. includes place-based information, especially about local communities;

c. is displayed using the latest mapping, search and presentation tools;

d. is "tiered" to allow users to access information at the level of detail they require (from easy-to-understand information to more complex presentations or, if necessary, the basic data); and,

e. balances provision of information in electronic formats with investments in other mechanisms for sharing information.

Increasing Public Awareness and Education

Once the partners in CISE have established public access to environmental information over the Internet, a Canada-wide campaign should be launched to tell Canadians where to find environmental information and why they need it. To reach Canadians in all their diversity, the campaign should use a variety of media, appropriate languages and credible spokespersons.

This awareness should also be increased through the educational system. In response to a United Nations Educational, Scientific and Cultural Organization (UNESCO) request for countries to develop strategies for environmental education, Environment Canada consulted 4,000 Canadians to gather input for the development of a national strategy. The results revealed that citizens feel environmental education should involve life-long learning opportunities for all generations and sectors, within and beyond the classroom walls. The consultation also showed

that trans-disciplinary approaches are needed to reach citizens where they are and traditional and local ecological knowledge should be valued, honoured and practically applied. The information resources in CISE should support the development of tools for learning about the environment both in the classroom and throughout life.

Recommendation

8. Implementation of CISE should involve:

a. a public awareness campaign to inform Canadians what environmental information is available, where they can find it, and why they should use it; and

b. supporting the development of tools for learning about the environment in classrooms and throughout life.

Encouraging Public Involvement

Experience has shown that providing environmental information is a necessary but insufficient requirement for changing the behaviour of people, or persuading them to take steps that will conserve or protect the environment. What seems to succeed in involving people is "community-based social marketing" in which "community champions" or "information intermediaries" or "opinion leaders" put together concerted local campaigns to change behaviour.[4] Community champions can be NGOs or non-profit organizations or municipal governments, or even federal or provincial agencies who take data or information from providers and use it to produce their own products or campaigns as a means of influencing behaviour.

Successes of Community-Based Social Marketing

"...when community-based social marketing approaches were applied in Durham region, residential water use dropped by 26%. Similarly, when this approach was applied to vehicle idling in Toronto, the number of vehicles observed idling was decreased by 32%, while the length of time that vehicles idled was decreased by a staggering 73%."

McKenzie-Mohr Associates
February 2001

CISE should provide these community champions with information and tools to assist them in delivering successful programs for environmentally related behavioural change. These could include information and tools to identify and overcome behavioural barriers to change, as well as to aid in the design and evaluation of the effectiveness of programs. CISE could also provide web-based tool kits to support such campaigns and make available best practices on the conduct of such campaigns.

Recommendation

9. CISE should encourage public involvement in environmental activities through support for community champions by making available:

a. information on the benefits of, and barriers to, encouraging specific kinds of environment-friendly behaviour;

b. information on best practices in the conduct of campaigns to encourage such behaviour; and

c. web-based tool kits to support such campaigns.

6. Need for Public Discussion

In the preceding chapters we have provided you with our preliminary thoughts on a Canadian Information System for the Environment. We have described the structure of CISE as a distributed system and identified who we believe should be partners in this network. We have listed the types of standards that will be needed to share and integrate data. We have offered our preliminary thinking on the means to obtain data resources more efficiently and effectively. We have described the role we believe CISE should play in enabling effective policy decisions, in engaging citizens and communities, and in encouraging public involvement. Although we have made progress in these areas, we know there is much left for us to do as we focus the scope of CISE and identify the priorities for its implementation.

Through these initial deliberations, we have become convinced that moving forward with CISE is crucial as a means of supporting environmental agencies in Canada as they move to a new style of environmental management. Although we feel there are many benefits to be realized, proceeding with CISE will not be without risks. It will demand change to an approach that has become quite comfortable for governments, the private sector, NGOs and the public. It will require a degree of inclusiveness and public transparency and disclosure that may be unprecedented in many agencies. It will involve the risks associated with experimentation. It will require some new investment. It will require a strong demand by the users and attitudinal changes on the part of providers to make it a reality. Ultimately, it may cause some realignment in federal and provincial priorities.

4 See McKenzie-Mohr Associates, *Influencing Behavior by Providing Environmental Information* (Prepared for the CISE Task Force, February 2001).

Federal departments, provincial and territorial ministries and other potential partners are making, and will continue to make, investments in new information systems designed to fit their business needs. We believe that without a vision for how to share and integrate information, such as we are recommending for CISE, a unique opportunity for joint progress will have been missed.

In the next few months, we will be holding consultations across Canada with key users and providers of environmental information. We urge you to improve upon our thinking by giving us a fuller picture of your environmental information needs and the kinds of measures that should be included in CISE to meet them. For your suggestions to be used in our final deliberations, we urge you to provide them to us by June 29, 2001. We will be putting forward our final recommendations to the Minister of the Environment in Autumn 2001.

Annex A: Members of the Task Force

David Johnston (Chair), President, University of Waterloo.

John ApSimon, Science Advisor to the Deputy Minister, Environment Canada.

Louise Comeau, Director, Sustainable Communities and Environmental Policy, Federation of Canadian Municipalities.

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Jennifer Hillard, Vice President, Issues and Policy, Consumers Association of Canada.

Lynne Howarth, Dean, Faculty of Information Studies, University of Toronto.

Mark Jaccard, Associate Professor and Director, Energy and Materials Research Group, Simon Fraser University.

Réjean Landry, Chair on Dissemination and Uptake of Research, Laval University.

Louis LaPierre, K. C. Irving Chair in Sustainable Development, University of Moncton.

David Lewin, Vice President of Government, Environment and Regulatory Affairs, EPCOR Utilities Inc.

Gordon McBean, Professor, Institute for Catastrophic Loss Reduction, University of Western Ontario.

John Millar, Vice President, Research and Analysis, Canadian Institute for Health Information.

Alan Nymark, Deputy Minister, Environment Canada.

Ken Ogilvie, Executive Director, Pollution Probe.

Richard Paton, President, Canadian Chemical Producers' Association.

John Riley, Chief Scientist, Nature Conservancy of Canada.

Stuart Smith, Chair, National Round Table on the Environment and the Economy.

Bruce Stein, Vice President for Programs, Association for Biodiversity Information.

Derek Thompson, Deputy Minister, Ministry of Environment, Lands and Parks, British Columbia.

Annex B: Possible Conceptual Frameworks

As mentioned in Chapter 2, we are considering different conceptual frameworks for CISE. Below are descriptions of two possible frameworks, natural capital and pressure-state-response.

Natural Capital Framework

According to the natural capital framework, the environment contributes to human welfare through the provision of material and service flows. For example, the metals used in producing so many of the products we require and enjoy originate in material flows from the environment. Similarly, the environment offers services that we use both directly and indirectly ranging from the provision of renewable resources, like fresh water, to the regulation of the global climate. The distinct stocks of natural resources and the individual ecosystems that are the sources of these material and service flows are collectively labeled *natural capital*.

There are three main categories of natural capital: renewable and non-renewable resource stocks (i.e., sub-soil resources, timber, fish, wildlife and water), land and ecosystems.

- **Renewable and non-renewable resources:** Renewable and non-renewable resources represent stocks from which

materials can be withdrawn for use in human activity. These materials provide inputs into industrial processes and other human activities (home heating, for example). Non-renewable resources are subject to permanent depletion as the result of use; they are not subject to qualitative degradation.[5] Renewable resources can be exploited without permanent depletion under appropriate conditions. These conditions do not always exist however and depletion of renewable resources is often a reality. In addition, they are subject to qualitative degradation from human activity (e.g., reductions in species diversity in forests from harvesting activities).

- **Land:** When land is considered as natural capital, it is with reference to its role in the provision of space for human activities (dwellings, transportation infrastructure, agriculture, recreation, etc.) and for the operation of the ecosystems upon which we rely.
- **Ecosystems:** Ecosystems (e.g., forests and wetlands) provide flows of unpriced services that are used by humans in a variety of ways. Industries and households, for example, use the waste assimilation services of rivers to absorb waste products that would otherwise have to be disposed of by another means at greater cost.

Human activities affect natural capital either through depletion or degradation. Depletion is the result of natural resource exploitation and land use change (when one form of land is converted to another). Degradation can also be the result of resource exploitation and land-use change, but also, importantly, of the introduction of waste products into the environment.

The natural capital framework can be operationalized through measurement of variables in three broad categories: stocks, flows and states. Key stock variables are the size of existing stocks of renewable and non-renewable natural resources and land types (e.g., agricultural land and forest land). These would be measured first in physical units (e.g., tonnes, hectares) and then, when possible, in monetary units. Key flow variables are the extraction of renewable and non-renewable resources, land-use change and emissions of wastes. These are also measured first in physical units and only when possible in monetary units. State variables are similar to stock variables except that the former are qualitative while the latter are quantitative. Key state variables are measures of the ability of ecosystems to provide essential services: clean air and water, productive soil, biodiversity, climate regulation, flows of renewable resources and protection from solar radiation. These variables are mainly measured in physical units and only with difficulty in monetary units.

Pressure-State-Response Framework

Another approach to organizing environmental information at a general level can be called the Pressure-State-Response (PSR) framework, after that used by the Organization for Economic Cooperation and Development for its core environmental indicators. It is not truly a single conceptual framework but a family of related frameworks, sharing similar features but adapted to particular circumstances and needs.

In its simplest and most common form, the PSR framework identifies three categories of environmental information:

- **Pressures** are human activities that can affect the natural environment, often organized along economic sectors. Pressures can include both direct environmental stressors, such as pollution or resource extraction, and underlying social and economic changes, such as population, transportation or consumption measures.
- **State** variables describe the quality of the natural environment and the quantity and quality of natural resources. They can also include measures of human health and broader quality of life.
- **Responses** refer to the ways in which society responds to environmental concerns, such as actions to reduce environmental pressures, conserve natural resources or restore ecological function.

The three categories are linked through a loose notion of causality. Pressures on the environment are believed to result in changes to its state. Recognition of these changes leads to societal responses which in turn are expected to reduce the pressures. It is recognized that the causal linkages must be interpreted cautiously, as the simple categories of the framework are unable to adequately explain the complex relationships within the natural environment and between the environment and human activity. Nonetheless, some understanding of causality is essential to environmental policy and to the identification of relevant environmental information.

Some organizations that have implemented a PSR framework have added categories of information or made the definitions of the categories more precise. The European Environment Agency uses a variant known by the acronym "DPSIR" in which "Driving Forces" are distinguished from more direct environmental pressures, and environmental "Impacts" are separated from societal responses. This approach also places greater emphasis on information concerning the linkages

5 Non-renewable resources are subject to qualitative as well as quantitative depletion. As sub-soil resources are extracted there is the need to exploit lower grades of minerals and deeper pools of fossil fuels, all of which are more costly to extract.

between categories. For example, the relationship between driving forces and environmental pressures is held to be a function of the eco-efficiency of the technology, thus suggesting possible indicators. The United States Environmental Protection Agency has added a category in their version of the framework for "Effects", which highlights information known about specific causal linkages among the other categories.

Since the categories are still quite broad the framework by itself does not provide sufficient guidance for the selection of environmental variables. In most cases it is combined with an issues approach in which priority environmental concerns are identified through a separate process and then mapped through the framework. An example of this is the application of the PSR framework by the United Nations Commission for Sustainable Development. Issues are drawn from the chapters of Agenda 21, and for each issue relevant indicators are identified under each of the three categories. The European System of Environmental Pressure Indices starts with a set of ten "policy fields" derived from the European Commission's Fifth Environmental Action Programme. Such narrowing of the information set by reference to a policy statements would appear to be essential to the practical application of the framework.

Annex C: Gaps in Environmental Information

In this Annex, we present a very preliminary analysis of the current gaps in environmental information. The list is not comprehensive, but it does reveal some of the most glaring gaps in the view of the environmental management officials[6] from the federal government from whom we requested input. We hope to refine and expand this list during our consultations with provinces, territories and other interested parties.

Our analysis demonstrates clearly that much of the information needed to make effective policy decisions requires additional development. We believe that over the next several years, governments will have to invest heavily in research and monitoring in order to fill these gaps and provide a solid base in information for their efforts to protect the health of Canadians and the health of Canada's ecosystems. One purpose of this annex is to encourage discussions and cooperation with respect to developing the needed information.

The gaps are listed below by environmental media – that is, air, water, and so on. The categories are not mutually exclusive because many issues, such as pesticides, pollution or biodiversity, manifest themselves across many media and can only be tracked in this way. ***The gaps identified below are primarily in monitoring and surveillance programs, though a few relate to research requirements. All represent areas where Canada does not now have the comprehensive national data sets required for informed decision making.***

1. Air

- enhanced national air quality monitoring of the pollutants causing smog;
- national air quality forecasting program that would provide the information needed to help Canadians make the choices that will protect their health and improve air quality;
- atmospheric research into the composition, transport and transformation of air pollution from sources and into ambient air to inform air quality predictions;
- development of models that can represent complex air pollutants in the Canadian atmosphere for use in the design of cost-effective emission reduction planning;
- better understanding of how air quality affects human health as a basis for standards and risk management decisions;
- expansion of the Canadian Air and Precipitation Monitoring Network and the National Air Pollution Surveillance Network to improve monitoring and reporting to Canadians on the growing problem of air pollution; and
- monitoring capacity that would allow estimates of the emissions of particulate matter from agricultural sources (for example, cropland and feedlot operations) as an information foundation to help the agri-food sector reduce risk and promote action towards solutions.

2. Climate

- research on the effects of climate change on variations in water levels and subsequent impacts on water quality;
- indicators of the effects of climate change on certain ecosystems (for example, northern ecosystems and wetlands);
- research on the effects of UV-B radiation on ecosystems;
- effect of predicted climate-change scenarios on the sustainability of agricultural production;
- monitoring of greenhouse gas emissions from existing technologies in the agricultural sector, as well as studies on alternative technologies to reduce those emissions;
- information to assess effects of transportation, including user response to some measures aimed at reducing transportation activities, shifting travel between modes and shifting to different fuels, as well as descriptions

6 We would like to thank officials at the following agencies: Environment Canada, Industry Canada, Agriculture and Agri-Food Canada, Indian and Northern Affairs Canada, Natural Resources Canada, Fisheries and Oceans Canada, Transport Canada, Parks Canada, Health Canada, the Canadian Institute for Health Information and Citizenship and Immigration Canada.

of the road vehicle fleet, its use and information on the number and use of off-road vehicles in Canada;
- expansion of the Cooperative Climate Network into certain areas (especially the north and mountainous regions) to enhance our ability to detect climate change and assess the state of the environment;
- more localized coverage by the monitoring network to determine localized impacts of a changing climate and allow proper decisions on adaptation (for example, changes in building and zoning codes or whether to restore a wetland that may dry out due to lower water levels);
- upgrading of obsolete data collection systems for supplementary climate (for example, rate of rainfall and radiation) monitoring programs that have deteriorated to the point that national assessments cannot be made; and
- increase in use of automation to replace the decreasing number of volunteers in the cooperative climate network (volunteers now operate half of the Cooperative Climate Network's 2,170 stations).

3. Water

- a national (federal/provincial/territorial) water quality monitoring system (network of networks) to provide comprehensive (surface and ground water) water quality information using up-to-date, nationally standard protocols for collection, analysis and data management, as a way of building an information base for the protection of source waters;
- monitoring systems on federal lands, including Canada's North (where microbiological pathogen monitoring in source waters is carried out in the proximity of less than five per cent of communities) and National Parks (which have more than 25 million visitors a year, while monitoring takes place in only 19 of 39 parks);
- monitoring of agricultural contaminants (such as pesticides, nutrients or endocrine-disrupting substances) in surface water and groundwater and assessing their impacts on ecosystems, particularly in areas of intensive agricultural activity (for example, 80 percent of Canadian pesticide use occurs in the prairie provinces, but currently no routine pesticide monitoring takes place. Meanwhile, concern over nutrients is rising due to the growing number of intensive livestock operations or factory farms);
- monitoring the performance of water treatment facilities to assess their effects on ambient water quality;
- research on the impacts of land use practices, municipal and industrial facilities, wastewater, and urban and industrial growth on the protection of sources of drinking water;
- research to develop hydrometeorological models to estimate and predict water quality;
- research to develop predictive models on water levels and flows;
- studies to determine the effectiveness of water conservation efforts;
- development of a water quality index and other performance-based reporting mechanisms to communicate water quality results to Canadians;
- expansion of the national water quantity monitoring system to provide coverage in Canada's North (where the greatest impacts of climate change are expected) and in northern Ontario and Quebec (where large areas are exposed to development without adequate information to make sound decisions);
- co-location of water quality and water quantity monitoring sites in key areas, because quantity often directly affects quality;
- water management at farms and food processing facilities (for example, irrigation methods and quantities of water used) to determine the impacts on the environment; and
- national large-scale mapping of watersheds.

4. Biodiversity

- development of standard national classifications for terrestrial and inland water communities, including a national vegetation classification system, as a means of facilitating landscape-level approaches that conserve and use biological resources in a sustainable fashion;
- rebuilding of Canada's taxonomic capacity, including digitization of key natural history collections essential for identifying and controlling invasive alien species and identifying and conserving species at risk;
- monitoring and assessing the health and status of species at risk and invasive alien species, in order to anticipate and prevent declines in species, the disappearance of habitat and the degradation of ecosystems;
- modeling of the potential ranges of native and invasive species;
- development of a common benchmark set of data to be tracked through the network of Conservation Data Centres, as a basis for roll-ups to the eco-region or national level, as well as for landscape-level conservation planning and project-specific environmental assessments;
- updated and comprehensive ecological inventory of national parks;
- improved capacity to monitor and report on the health and status (i.e., biodiversity) of, and within Canada's forests, protected areas, and agricultural areas;
- amount and location of critical habitats, such as wetlands and woodlands, in agricultural areas;
- studies on the risk to biodiversity and health of ecosystems from farm practices (such as pesticide use);
- status of domesticated biodiversity (such as farm animals or crops) to assess the potential, and impacts, of the use of genetically modified organisms; and
- research to develop methodologies for measuring the integrity of ecosystems.

5. Human / Environmental Health

- studies on the possible effects, particularly to children, of risks from pesticide use in agriculture;
- development of a national surveillance system to quantify the incidence and impact of waterborne diseases on human health as a basis for detecting, predicting and preventing illness (i.e., enhance the ability to link source water quality to drinking water products, shellfish and fish, and processed food to human health outcomes);
- production of routinely collected drinking water quality data in a standardized, comparable format at the community level across the country;
- research to develop standard testing procedures for routine testing for some of the organisms that represent significant risks for widespread epidemics leading to considerable morbidity and mortality. Organisms such as cryptosporidium, giardia and toxoplasmosis have been the cause of extensive outbreaks in the United States and Canada in recent years, causing considerable morbidity and sizable social and economic costs. Standard testing procedures do not detect these organisms and there is now no cost-effective way of routinely testing for them;
- monitoring of small particulate (with a particle size 2.5 microns and smaller) air pollution in order to produce routinely available, standardized data from health regions across the country. This aspect of outdoor air quality is currently viewed as having the most impact on human health;
- development of warning systems (to provide, for example, heat alerts and cold alerts) for municipalities so that they can take measures to warn people at risk (such as children or the elderly) and implement emergency plans (such as power conservation measures or provision of air-conditioned centres for elderly people without air conditioners at home);
- monitoring and analyses at a global and intergenerational level of the interaction between human health and the environment; this could include monitoring of the emerging interactions between human capital, social capital, production and productivity, natural capital stocks and flows, pollution levels and ecological integrity;
- maintenance and enhancement of weather and warning services, including the radar network, increased use of Doppler radar, replacement of older automatic observation sites; ensuring Canada can meet its commitments to the World Meteorological Organization;
- development of indicators of sustainable and non-sustainable development, particularly in the social dimension of sustainable development (i.e., indicators of absorptive capacity or the carrying capacity of particular communities); and
- improved data on the economic, social, and environmental impacts of population growth, urbanisation, resource use, and the environmental behaviours of newcomers to Canada.

6. Resources

Many of the environment-related gaps in agricultural information have been addressed under water and air, as well as land below.

Wildlife

- monitoring and assessment of the health and status of wildlife and their habitats, with priority given to migratory birds, in order to anticipate and prevent the decline in species, the disappearance of habitat and the degradation of ecosystems;
- assessments of the status of butterflies, moths and molluscs to determine whether they are at risk; and
- monitoring to provide information on the spatial and temporal trends in the movement and fate of toxic substances and other substances affecting wildlife, especially in certain ecosystems (such as the sensitive ecosystems of the north).

Fish / Marine

- assessment of status of fish stocks and habitat for conservation and sustainable economic use of Canadian fishery resources;
- research on the interactions between wild and cultured stocks to support the environmental sustainability of aquaculture;
- research into the functioning of marine ecosystems;
- research and monitoring of the effects of natural and human activities on marine ecosystems including environmental threats such as the toxins and contaminants in the ecosystems that affect human health, and the many land – and sea-based activities that may damage the ocean environment;
- monitoring of wild and cultured stocks of finfish and shellfish for diseases; and
- improvement in marine data (which in some cases is fragmented), such as the processing of quality control and archiving of marine climatological data and volunteer ship program data.

Land

- national program monitoring land cover with field surveys, large-scale photography and remote sensing technologies to assess the impacts of changes in land use on wildlife habitats, carbon sinks, water yield and quality, and the stability of the climate system;
- information over time on changes in land cover and use, particularly estimates of the expansion of agricultural lands and changes in forest lands;
- digital base maps for most of the territories, especially in areas of active development, to encourage participation by citizens and interest groups in review and planning of developments;

- geological mapping of surface features in the territories;
- standardized, national map of "protected" lands and waters, public and private;
- updating of soil surveys (since most are more than 40 years old) to support soil management decisions related to agricultural production, habitats, etc.;
- location of existing agricultural operations to support local decision-making on locations for new development consistent with a healthy environment and sustainable use of land and water;
- use of land for transportation;
- amount and location of land protected for soil and water conservation; and
- monitoring of sources of radioactivity (e.g., radon gas).

Forests

Canada must better equip itself to describe its forest resources and the effects of activities taking place within them, with the view to enabling more effective decision-making with regard to sustainability, and enabling Canada to better report against domestic and international commitments. Requirements include:

- updating and ground proofing of the national forest inventory (species, age classes, protected forest lands, etc.);
- improving the capacity to present more timely and accurate representation of Canada's forests and sustainability (changes in forest cover, harvest levels, regeneration, rates of growth, etc.); and
- increasing the ability to authoritatively respond to domestic and international questions regarding sustainable forest management in Canada, and to respond to misinformation that may evolve.

Minerals and Metals

- maintenance and expansion of current mechanisms for gathering information on the flows of recycled/recyclable materials in Canada, including minerals and metals, as well as wood-based and petroleum-based products;
- development of indicators to measure progress toward sustainable development in minerals and metals which address the environmental goals and objectives outlined in the *Consultation paper on Canadian Values Underlying the Sustainable Development of Minerals and Metals*. To this end, information is required on the impacts/contribution of the minerals and metal industry on:
  - -pollution prevention;
  - -mine site reclamation and rehabilitation;
  - -wildlife habitat; and
  - -protection of ecosystems and endangered species.
- effects of acid mine drainage and metal leaching on watersheds and ecosystems, and the direct link to human health and human socio-economic well being;
- impacts/contribution of mineral development on the environment and communities in the short and long run;
- information on the development and take-up of alternative sources of materials and energy;
- information on technical options and choices for addressing environmental issues in order to expand decision-making capabilities;
- inventory of inactive mine sites;
- regional background levels of metals in water and soils;
- aquatic environmental effects monitoring of metal mining; and
- life cycle information regarding minerals and metals for use in life cycle assessments.

7. Eco-efficiency

- statistics on the quantities and types of solid waste and hazardous and non-hazardous waste produced in Canada;
- data base on resource use and eco-efficiency to facilitate life-cycle analysis, benchmarking and development of indicators for the manufacturing and resource industries;
- improved data on activity related to the transportation of dangerous goods; and
- inventory of wastes by region, related.